



Early Journal Content on JSTOR, Free to Anyone in the World

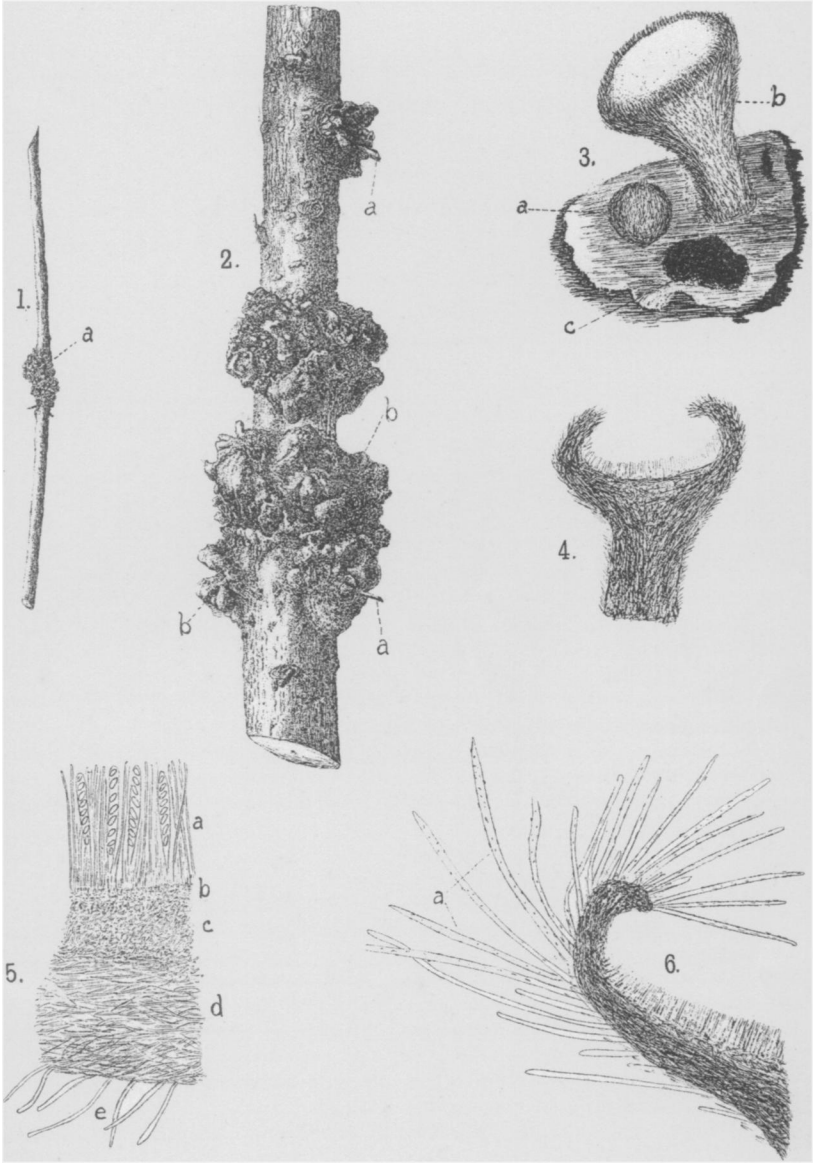
This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

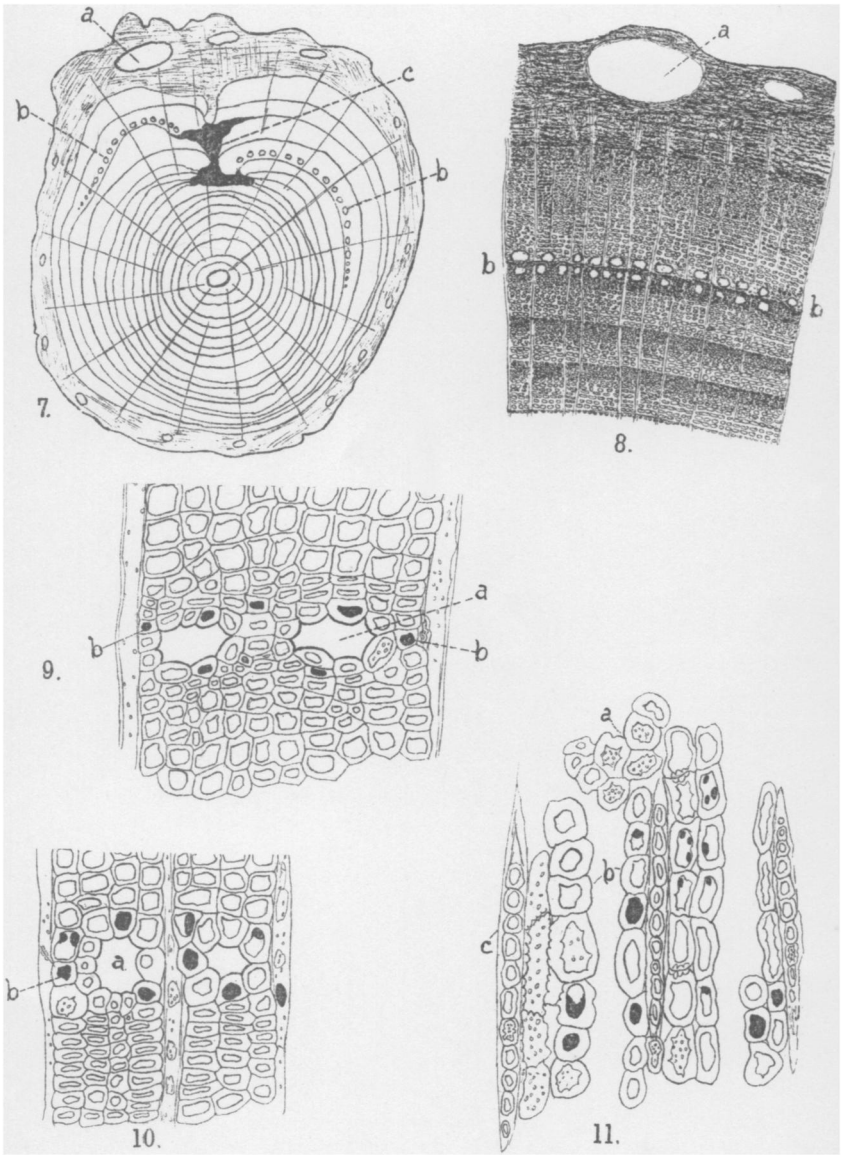
Read more about Early Journal Content at <http://about.jstor.org/participate-jstor/individuals/early-journal-content>.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.



DASYSCYPHA RESINARIA

HELIOTYPE CO., BOSTON.



Dasyscypha resinaria causing Canker Growth on *Abies balsamea* in Minnesota

BY ALEXANDER P. ANDERSON

(WITH PLATES I AND 2)

In the fall of 1896, while collecting plants in the vicinity of Walker, on Leech Lake, northern Minnesota, the writer noticed that the trunks and larger branches of *Abies balsamea*, which grows abundantly in the bogs around this place, were affected to a great extent with some fungus or insect, producing numerous canker-like growths and swellings on the stems. This was true especially of the lower part of the tree trunks, and around the branches that had been shaded out and had died on account of an insufficient amount of light. On some trees almost every knot and dead branch was surrounded by one or more of these canker swellings, the canker not infrequently extending all around the tree trunk, or branch (*fig. 2*). When younger stems or branches were affected in this way the portion above the canker, and often the whole stem, had been killed by the girdling (*fig. 1*).

The trees and cankers were carefully examined, to see whether the cause of the deformation might not be due to insects, like the one causing the common tumors and "witch-brooms" on *Picea nigra* * which also grows in the bogs of northern Minnesota. No *Chermes* nor other insect of any kind was present on the affected trees, nor could any indications of any be found, either on the surface of the trees, or on the inside of the bark and wood.

The rough bark of the canker was found to have on it, numerous ascomata (*fig. 3*) which were very similar to those of *Dasyscypha calycina* (Schum.) Fuckel (*D. Willkommii* Hartig), the com-

* These "witch-brooms" on *Picea nigra* sometimes become a meter or more in diameter and are usually spherical, when full grown. They are caused by some species of *Chermes*—probably *Chermes abietis*. Compare von Tubeuf, Forst-naturw. Zeitschr. 2: 76. pl. 5. 1893; Anderson, A. P., Bot. Gazette, 24: 312. 1897; and Brodie, W., The spruce Gall-louse, Ontario Department of Agriculture Bureau of Forestry, Toronto, May 1, 1893. In the last, mention is made of *Chermes abietis* as occurring on *Picea nigra* and *Abies balsamea* in Canada.

mon larch canker-producing fungus of Europe, which were familiar to the writer in their living and natural condition. The canker swellings and deformations had much the same appearance as those caused by *D. calycina*, especially in the profuse resin exudation and flow from the wound.

The external character of the canker-swellings and the presence of the ascomata, which were found only on the affected parts, led me to believe that the fungus, if not *D. calycina*, was a parasitic one, closely related to the larch canker, *Dasyscypha*, of Europe.

Material of the affected stems and fungus was collected at the time, which has since been worked up. The more important characters of the fungus and its effect on the stems are given in this paper.

THE FUNGUS

The ascomata are found only on the bark of the canker-swellings and deformations on living trees or on the similar swellings on branches and stems which have recently been killed by the cankers. The fungus is not present on the bark of any other part of the tree.

The ascomata are stipitate when mature, but sessile in their developing condition (*fig. 3, a*). The cups of immature and mature ones are approximately of the same diameter—one-half to one millimeter across. The stipe varies from one-fourth to one millimeter in length. The whole ascoma is covered over with pilear hairs (*fig. 3*), which are longer and more abundant on the cup, especially around the disc, than on the stipe (*figs. 4 and 6*).

The hairs, which surround the disc, project upwards perpendicularly to the disc when the ascoma is wet or moistened, but when in a dry condition the hairs of the fringe are turned inwards and almost cover and exclude the disc from view. The reason for this movement will be explained later in the paper. The disc is slightly orange colored, seen best in younger ascomata, soon after they have opened. The stipe and surface of cups of mature ascomata are grayish, becoming whitish and more easily seen on the bark, when in a dry condition. The ascomata, although of a leathery consistency, become brittle and easily drop off when dry.

Sections of the ascoma shows it to correspond, in its structural

characters, to those of the Helotiaceae, so well described and figured by Durand,* and to the genus *Dasyscypha*.

The asci are small, cylindrical and slightly club-shaped, tapering at the base, and becoming broader towards the rounded apex. They vary in size from 2.5×20 to $4 \times 30 \mu$. The ascus wall is extremely hyaline and difficult to find and measure. It can usually be made out, however, in thin sections, from the position of the spores which lie eight in a row, appearing as if the ascus wall had dissolved away, leaving the spores in their position (*fig. 5*).

The spores are elliptical and extremely small. They vary somewhat in size, the lower ones of the ascus being smaller than the ones nearer the apex. Measurements of spores in several asci gave the following: $1.66 \times 2.5 \mu$, $1.95 \times 2.6 \mu$, $2.07 \times 3.0 \mu$, $2.29 \times 3.07 \mu$, $2.49 \times 3.5 \mu$.

The paraphyses are cylindrical, tapering slightly at the base and are rounded at the tip; otherwise they are of the same diameter throughout. They are about one and one-half to two times as long as the asci, and vary in diameter from 0.8 to 1.5μ . The asci and paraphyses are free at their ends, there being no epithecium present.

The hypothecium consists of a thin layer of closely interwoven and extremely slender hyphae, which are made out with difficulty.

The excipulum (peridium) is made up of two not clearly differentiated portions, the medullary and the extal. The medullary consists of more loosely interwoven, colorless hyphae, which run in all directions, filling up the upper central portion of the stipe and forming a thin layer below the hypothecium. The extal layer of the excipulum consists of longer, thick-walled and closely interwoven hyphae, which are more regular in their course, running almost parallel with each other and with the surface of the ascoma. Some of the extal layer hyphae change their course or become separated from the other and project from the surface of the ascoma, forming the so-called hairs or pili. These pili or projecting hyphae have a greater diameter (3 to 4μ) than any of the extal

* Durand, Elias J., The classification of the Fleshy Pezizineae with Reference to the Structural Characters illustrating the Bases of their Division into Families. Bull. Torrey Club, 27 : 481. 1900.

hyphae (1 to 2 μ), from which they grow. The pili are shortest on the stipe of the ascoma (40 μ long) and longest on the margin of the cup (80 μ), where they form a fringe of hairs which project vertically upwards, when the cup is moist and open, but are turned inwards, almost covering and meeting in the center of the disc, when the ascoma is dry (*fig. 6*).

This movement of the fringe of pili, surrounding the disc, is a hygroscopic one, due to tissue tensions. Thus the longer, thicker-walled and more compact peridial hyphae, running up and down and almost parallel with each other and with the surface of the ascoma, would, on drying, contract less than the medullary portion, consisting of loosely interwoven and thinner-walled hyphae, running more or less in all directions. As a consequence, when the ascoma dries the greater contraction of the medullary portion tends to pull in, or draw down, the hymenium, making it more concave, and at the same time causing an inward curvature of the fringe of hairs which project from the margin of the peridial portion extending around the hymenium. The pili or projecting hyphae, forming the fringe, do not curve, but remain at the same angle to the peridial substratum which makes this hygroscopic movement.

The pili, projecting from the surface of the ascoma, especially those forming the fringe around the disc, are dotted over with minute particles of, what appears to be calcium carbonate (*fig. 6*). The particles disappear when sections are placed in a weak solution of either acetic or hydrochloric acid. I have not been able to notice any evolution of carbon dioxide from acid treated sections under the microscope. The differences in color of the ascoma in its wet and dry condition, is due partly to the presence of these particles on the pili.

IDENTIFICATION OF THE FUNGUS

The ascomata, as well as the cankers, in their external characters, resembles those of *Dasyscypha calycina* (Schum.) Fuckel, which has been found in the United States. It was collected by Judge Peters in Alabama, on *Pinus*.* Tubeuf also states that the

* Underwood, L. M., and Earle, F. S., A preliminary List of Alabama Fungi. Bull. Ala. Agric. Exp. Sta. 80: 202. 1897.

larch canker *Dasyscypha* occurs in the United States* and further that it is the only parasitic species in the genus *Dasyscypha*. Since the publication of Tubeuf's "Pflanzenkrankheiten," however, Wagner† has found that *Dasyscypha calyciformis* (Willd.) Rehm, is parasitic on *Pinus silvestris*, *Abies pectinata* and *Picea excelsa*, in Germany. These two are the only parasitic species of *Dasyscypha* that have heretofore been reported, but there can be no doubt but that more of the ones inhabiting the bark of living trees, will be found to be parasitic, when a careful examination of these is made

That the Minnesota *Dasyscypha* on *Abies balsamea* is neither *D. calycina* nor *D. calyciformis*, is shown by the extreme minuteness of its spores, which are smaller than those of any of the species which it resembles. The ascoma resembles that of *D. Agassizii* B. & C., but is much smaller. The size of the ascoma, as well as that of the spores, agrees most closely with those of *D. chamaeleontina* (Peck) Sacc. described by Peck‡ from specimens collected at Sandlake, New York, on the under surface of hemlock-wood lying on the ground. Peck states that there is scarcely any appearance of hairiness on the cups, and that when the cups are bruised, they change in color from white to yellow, then to pink or red. The cups of the Minnesota *Dasyscypha*, do not change in color when crushed, nor are its spores "stipitate" as in *D. chamaeleontina*.

All the characters of the Minnesota *Dasyscypha* correspond most closely with those of *Dasyscypha resinaria* (Cook and Phil.) Rehm., which has been found in North Wales and in Hungary. It resembles this species so closely that there can be no doubt as to its being this one. In the following table, comparisons are made between the closely related species:

In the original description of *D. resinaria*§ the size of the spores was given as $5 \times 2.5 \mu$. This was found by Masee|| to be too large, as shown by the following, copied from Masee's de-

* Tubeuf, K. von, Diseases of Plants induced by Cryptogamic Parasites. English translation by Dr. W. G. Smith, 271.

† Wagner, G., Beiträge zur Kenntniss d. Pflanzenkrankheiten. Zeitschr. Pflanzenkrankheiten, 6: 321. 1896.

‡ Peck, C. H., Reg. Report, 30: 60.

§ Grevillea, 3: 185. 1875; and Phillips, British Discomycetes, 242. 1887.

|| Masee, George, British Fungus Flora, 4: 344.

	D. CALYCINA (Schum.) Fuekel. (<i>D. Willkommii</i> Hartig.)	D. AGASSIZII B. & C.	D. CHAMAELKONTINA (Peck) Sacc.	D. RESINARIA (Cooke & Phil.) Rehm.	Minnesota Dasyscypha. D. RESINARIA (Cooke & Phil.) Rehm.
Ascomata.	Gregarious and scattered. Stipitate, hairy; hairs 100 to $150 \times 4 \mu$.	Bunched or fascicular. Only slightly stipitate and hairy.	Shortstiped and slightly hairy.	Gregarious and stipitate. 1.5 mm. high. Externally whitish and hairy; hairs unbranched; septate and with particles of CaCO_3 ; unbranched.	Gregarious and stipitate. $1-1.5$ mm. high when mature. Externally grayish and hairy; hairs $40-80 \times 3-4 \mu$; septate (?) and unbranched.
Disc.	Expanded when moist. Concave when dry. $1-3$ mm. broad. Orange yellow.	Flattened when moist. Concave when dry. Margin undulating. $1-3$ mm. broad; orange.	Disc expanded. $0.13-0.5$ mm. broad; reddish.	Margin usually incurved; $.75-1$ mm. across. Concave; pale orange.	Margin incurved when dry, but open when moist; $5-1$ mm. across; concave when dry; pale orange.
Asci.	Cylindrical, obtuse and 8-spored.	Subcylindrical.	Clavate. $25-35 \mu$ long.	Small, cylindrical and clavate; 8-spored.	Small, cylindrical, clavate. $2.5-4 \times 20-30 \mu$. 8-spored.
Spores.	Elliptical-fusiform. $18-25 \times 6-8 \mu$.	Elliptical. $6.5-7.5 \times 4 \mu$.	Oblong-ovate. Subulate and stipitate. 5μ long.	Elliptical and hyaline, smooth, $3 \times 1.5-2 \mu$. $5 \times 2.5 \mu$ according to Phillips.	Elliptical and hyaline, smooth; $3.5-2.5 \times 2.4-1.6 \mu$.
Paraphyses.	Slender and cylindrical.			Slender; 15μ thick; longer than the asci.	$0.8-1.5 \mu$ thick; longer than asci.
Habitat.	On <i>Pinus</i> and <i>Larix</i> . Europe and United States, America.	On <i>Abies</i> . Lake Superior, etc., and an <i>Pinus contorta</i> in California.	On <i>Thuja Canadensis</i> , Sandlake, N. Y.	On <i>Abies excelsa</i> in N. Wales and in Hungary.	On <i>Abies balsamea</i> at Walker, Minnesota.

scription: "Described from specimens in Phillip's *Elv. Brit.*, no. 66. The size of the spores— $5 \times 2.5 \mu$ —as given by Phillips in *Disc. Brit.*, is certainly too large. I have never found them above 3μ long."

The spores of the specimens found in Hungary were $3 \times 2.5 \mu$; also smaller than the size given by Phillips in his description, but of same size as spores of specimens found in Minnesota.

No European specimens of *D. resinaria* have been examined by the writer, but the descriptions of it correspond so closely with the Minnesota *Dasyscypha*, that there can be little doubt about the two being the same species.

THE CANKER

The characteristic smooth bark of *Abies balsamea*, becomes rough at the canker spot, by the formation of ridges and bark projections, soon after the infection has taken place. The outer bark (peridium and epidermis) does not become hypertrophied, but is broken through, and scales off, sooner than normally, on account of the increased growth of the inner layers of the bark, which become hypertrophied.

PRIMARY CORTEX (MIDDLE BARK)

In the bark of the canker, the periderm as well as the primary cortex, and outer layers of the secondary cortex, are very soon cut off by the formation of a new phellogen layer. This causes the death of the cut-off layers of the bark which dry up sooner than in the normal. The resin-canals are also cut off and disturbed and their resin contents begin to diffuse into the surrounding tissues, but mostly collect in the resin-vesicles or "blisters," which are also formed sooner in the primary cortex of the canker than in the normal bark. The vesicles of the canker depart from the normal, especially in their size (*figs. 7 and 8*), being either abnormally large or small. The resin of the canker vesicles is forced out by the increased pressure on the vesicle, by the shrinkage of the surrounding dead layers of the bark, cut off by the new phellogen. The resin thus forced out runs down the trunk of the tree, the more volatile substances evaporating, leaving the solid resin, which hardens and gives the

trunk a glazed appearance easily seen at some distance from the tree. The exudation of resin from the canker spot, however, is not due entirely to the early drying and forcing of the resin out of the vesicles, but also to an increased resin secretion at the cambium and parenchyma cells of the secondary cortex. The resin-canals and vesicles for the storage and reception of the resin having, as explained, already been cut off, a part of this resin diffuses into the outer dry bark but the remainder is forced to the surface where it collects in drops (Fig. 3, *e*) which hardens as soon as exuded, or when the exudation is profuse a part of the resin flows down the trunk.

THE SECONDARY CORTEX (INNER BARK)

The cambium at the canker spot produces an increased number of cortical as well as wood-cells. The secondary cortex does not depart much from the normal in its structures, except in its increased thickness, often eight to ten times that of the normal, due to the greatly increased number of cells formed. The secondary cortex is normal in that it does not contain any resin-canals nor resin-vesicles.

THE WOOD

The annual rings of the wood formed at the canker are wider than those formed before the infection. This increased width of the rings is due to an increase in the number of tracheids produced by the cambium. These tracheids, as well as the cells of the medullary rays, are usually of a greater diameter than the normal, which also accounts for the greater width of the rings formed at the canker.

This increased growth of wood and cortex takes place anywhere the cambium still remains alive. In all of the cankers examined, the cambium had been killed, usually about the center. The dead spot varies in size in different cankers but it seldom extends completely around the stem or branch. When it does, as in *fig. 1*, the branch becomes girdled at this place and soon dies. More often the dead area is small, remaining about the same size for a period of years. An effort is made by the living cambium surrounding the dead area to heal it over. This it is not able to do on account of the fungus mycelium. With the increase in the

number of annual rings of the wood a cavity or pocket is thus formed at the dead spot. Often several such cavities are formed when the cambium has been killed at more than one spot. All these cavities or pockets are always filled with hardened resin, forming one or more resin-pockets or "resin-galls." *

These resin-pockets are formed at first between the bark and wood where the cambium has been killed, but they are later enclosed in the wood by the formation of new annual rings of wood (*fig. 7*).

The normal wood of *Abies balsamea* does not contain any resin canals, but in wounded and hypertrophied wood, such organs are not infrequently formed. The writer has already called attention to the occurrence of pathogenic resin-canals in the tumors formed by *Aecidium elatinum*, when affecting the branches of *Abies balsamea*. †

The wood of the canker invariably contains pathogenic resin-canals, which are similar to those formed in tumors caused by the *Aecidium* (*fig. 10*). The canals are all vertical ones, no horizontal canals are formed. The canals vary in diameter from 25 to 85 μ and in length from a few millimeters to 2-4 centimeters. They do not extend through the whole length of an internode or year's growth, like the normal resin-canals of *Pinus* and *Picea*. In the wood of *Abies* the canals are formed in groups or chains on one side of an annual ring and usually in the spring wood (*figs. 7 and 8*). Usually only one chain or ring of canals is formed each year, but sometimes two are formed in the same ring, one in the spring and one in the fall-wood zone. Not infrequently, a chain of canals is formed in the fall at the end of the growing season and another one the following spring in the new wood (*fig. 8*). In this case, it seems that the abnormal resin secretion, necessitating the formation of the canals, begins in the late fall or summer, when it is not completed, but continues the following spring. A new set of canals are now formed at the cambium, the canals formed in the fall having in the meantime become thick-walled and their resin contents hardened.

* It appears that resin-pockets would be a better term than "resin-galls" ("Harzgallen") with which to designate the solid masses of resin which are not infrequently found in the wood of the Abietineae, since the term gall conveys the idea of a visible hypertrophied living part of a plant organ caused mainly by insects and fungi.

† Bot. Gazette, 24: 337.

The canals of the chains are separated only by one or two medullary rays and very few tracheids are formed in the zone of the resin canal chain. The lining cells of the canals are of parenchymatic origin, shown by the numerous simple pits present in their walls. Wound parenchyma cells are always present in the canal zone. These cells are thick-walled and simple pitted and are best seen in tangential sections (*fig. 11*).

The lumina of many of the canal lining-cells are filled with hardened resin. The same is true also of many of the tracheids surrounding the canals. These "resin-cells" (*figs. 9 and 10*), are also present in the normal wood of *Abies balsamea*, but fewer than in the canker wood. They are not uncommon in the wood of other genera of the Abietineae.*

In trunks and branches with several canker spots (*fig. 2*) the wood of the apparently healthy portions of the stems between the swellings contains chains of pathogenic resin-canals. These chains are present in the apparently normal wood, even at a distance of 20 cm. from the canker spot (*fig. 9*). The formation of these canals is not due directly to the presence of the fungus mycelium, which does not spread more than one to two centimeters outside of the canker spot, but to the pathological condition of the whole tree when many cankers are formed on its trunk. The chains of canals in the canker-wood and those in the apparently normal wood at some distance from the canker are similar in every respect.

The resin-canals in the wood of *Abies balsamea* affected with this fungus are similar in their characters and distribution in the rings to the chains of canals found in the normal wood of *Abies firma* of Japan. According to Dr. Nakamura † the canals in the wood of *Abies firma* are formed only in the fall-wood zone, where they are arranged in a chain or arc, with approximately one canal for every four tracheids. Vertical canals only, and no horizontal ones, are formed. The cells lining the canals are also like those in *Abies balsamea*, thick-walled and provided with numerous simple pits.

The resin-canals in *A. balsamea* are similar also to those formed

* Mayr, Heinrich, Harz der Nodelpölzer, Berlin, 80 1894.

* Nakamura, Dr. Yaroku, Ueber den Anatomischen Bau des Holzes der Wichtigsten Japanischen Coniferen. Unters. Forst. botan. Inst. München, 3 : 17. 1883.

in the wood of branches of *A. pectinata*, produced experimentally by Nottberg * who fractured the branches by partly bending them. The characteristic canal chains were formed in the wood near the fracture, three months after the wound had been made.

Hartig † found the same pathogenic resin-canal chains in the wood of trees of *Abies pectinata* that had been injured by lightning.

Resin-canals in the wood of species of *Abies* appears to be not an uncommon occurrence. They are formed only when the wood has been wounded mechanically in some way or when it becomes hypertrophied by the presence of certain fungi at the cambium.

PARASITISM OF *DASYSCYPHA RESINARIA*

Although the writer has had no opportunity to make infection experiments with a view to determine for a certainty that the cankers formed on the trunks and branches of *A. balsamea* are caused by *D. resinaria*, there can be little doubt but that they are caused by this fungus, which is always found on the bark of the canker spots only and nowhere else on the trees.

Like the European larch canker *Dasyscypha*, *Dasyscypha resinaria* fruits on the canker bark after the branch or stem affected has been killed. As far as was possible to make out, this fruiting on the dead stems continues only for one season after the stems have been killed by the parasite. Dead branches which have dropped from the tree have no ascomata on them excepting on the canker spots, and on these only when the branch has dropped off within a year previous.

The absence of insects and the presence of the mycelium in the bark, as well as at the cambium of the canker; also the absence of the ascomata on the normal bark of the living tree, as well as on stems that have been dead for more than one year, seems, at present, to be sufficient evidence for including *Dasyscypha resinaria* among the parasitic species of this genus. The infection takes place, as a rule, around the base of the imperfectly self-

* Nottberg, Dr. P., Experimental-Untersuchungen Über die Entstehung der Harzgallen und Verwandter Gebilde bei Unsere Abietineen. Zeitschr. Pflanzenkrankheiten, 7 : 142. 1897. Also in Archiv der Pharmacie, 235 : 256. 1897.

* Hartig, Dr. R., Untersuchungen über Blitzschläge in Waldbäumen. Forst. naturwiss. Zeitschrift, 6 : 150. 1897.

pruned branches of the lower part of the trunk. At these places the spores gain access to the living inner bark and to the cambium, where they germinate and cause the increased growth of the wood and secondary cortex. Wounds caused by insects and by hail and by the breaking of the branches by snow and ice, also expose the cambium to the fungus spores.

Explanation of Plates 1 and 2

FIG. 1. Dead branch from affected tree, with canker swelling at *a*, completely surrounding the branch. Ascomata (not visible in the figure) are present only on the hypertrophied bark of the canker, $\frac{1}{8}$ natural size.

FIG. 2. Portion of affected trunk with three canker swellings; *a*, dead branch around which a small canker has formed and at the base of which the infection took place; *a'*, dead branch with older canker which has spread almost around the trunk; *b*, hypertrophied bark, consisting mainly of the secondary cortex, $\frac{1}{4}$ natural size.

FIG. 3. Magnified portion of bark, at canker, with unopened ascoma at *a*, and mature one at *b*; at *a* and *c* is shown a drop of exuded and hardened resin, $\times 30$.

FIG. 4. Section of ascoma, $\times 30$.

FIG. 5. Section of ascoma through hymenium and sterile portion; *a*, hymenium; *b*, hypothecium; *c*, medullary portion of excipulum; *d*, extal layer of excipulum; *e*, pili, $\times 450$.

FIG. 6. Portion of cup with pili forming the fringe around the disc; *a*, particles of excreted calcium carbonate with which these hairs are dotted over, $\times 125$.

FIG. 7. Cross section of stem, through canker; *a*, resin vesicle in primary cortex, larger than normal ones on opposite healthy portion of stem; *bb*, two chains of pathogenic resin-canals; *c*, resin-pocket formed where cambium had been killed; filled with hardened resin, $\times 1\frac{1}{2}$.

FIG. 8. Section through portion of canker; *a*, resin vesicle of greater diameter than normal; *bb*, two chains of pathogenic resin-canals, one in fall and the other in spring wood of the following year, $\times 15$.

FIG. 9. Part of cross section of apparently healthy wood, 6 centimeters below the canker spot; *a*, pathogenic resin-canals; *b*, "resin cells," lumina of which are filled with hardened resin, $\times 160$.

FIG. 10. Part of cross section of wood at canker, with pathogenic resin-canals (*a*) and "resin-cells" (*b*), $\times 160$.

FIG. 11. Tangential section through a chain of pathogenic resin-canals; *a*, wound parenchyma; *b*, lining cells of resin-canals; *c*, medullary rays, $\times 160$.